Relay and Protection of Power Transmission Lines

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ABSTRACT
In this article, the consumer is informed about the quality and non-ring transmission of electricity, the elimination of problems arising during the transmission, and the use of devices and tools such as trunk lines, bases, means of protection, in what way the electricity will come to the consumer and how it will be transmitted before consumption.

KEYWORDS: *electrical transmission lines, insulation, short circuit, maintenance, wire and cables, protective devices, relays.*

Uninterrupted and reliable transportation of electricity to consumers is one of the main tasks constantly solved by power engineers. To ensure it, electric networks have been created, consisting of distribution substations and power lines connecting them. To move energy over long distances, supports are used, to which connecting wires are suspended. They are isolated between themselves and the ground by a layer of ambient air. Such lines are called air lines by the type of insulation.

If the distance of the transport highway is small or for safety reasons it is necessary to hide the power line in the ground, then cables are used.

Overhead and cable power lines are constantly under voltage, the value of which is determined by the structure of the electrical network.

In case of damage to the insulation of any place of a cable or extended overhead transmission line, the voltage applied to the line creates a leakage current or short circuit through the broken section.

The reasons for the violation of isolation can be various factors that are able to withdraw themselves or continue their destructive impact. For example, a stork flying between the wires of an overhead power line created an inter-phase closure with its wings and burned down, falling nearby.

Or a tree that grew very close to the support, during a storm, a gust of wind knocked down the wires and shorted them.

In the first case, the short circuit occurred for a short period of time and disappeared, and in the second case, the insulation violation is of a long nature and requires elimination by the maintenance electrical personnel.

Such damages can cause great damage to energy enterprises. The currents of the resulting short circuits have enormous thermal energy that can burn not only the wires of the supply lines, but also destroy the power equipment at the supply substations.

For these reasons, all the damage that occurs on the power line must be eliminated instantly. This is achieved by removing the voltage from the damaged line on the supply side. If such a power line receives power from both sides, then they both have to turn off the voltage.

The functions of constantly monitoring the electrical parameters of the state of all power lines and

removing voltage from them from all sides in the event of any emergency situations are assigned to complex technical systems, which are traditionally called relay protections.

The adjective "relay" is formed from the element base based on electromagnetic relays, the designs of which arose with the appearance of the first power lines and are being improved to the present day.

Modular protective devices based on microprocessor technology and computer technology, which are widely introduced into the practice of power engineers, do not exclude the complete replacement of relay devices yet and, according to the established tradition, are also included in relay protection devices.

To track the electrical parameters of power transmission lines, it is necessary to have their measurement organs that are able to constantly monitor any deviations of the normal mode in the network and, at the same time, meet the conditions of safe operation.

In power lines of all voltages, this function is assigned to measuring transformers. They are divided into transformers:

- ✓ current (TC);
- ✓ voltage (TV).

Since the quality of the protection is of paramount importance for the reliability of the entire electrical system, the measuring TC and TV are subject to increased requirements for the accuracy of work, which are determined by their metrological characteristics.

The accuracy classes of measuring transformers for use in RPA devices (relay protection and automation) are normalized by the values "0.5", "0.2" and "P".

A general view of the installation of voltage transformers on the 110 kV overhead line is shown in the picture below.

It can be seen here that TV are installed not in any place of an extended line, but on the switchgear of an electrical substation. Each transformer is connected by its primary terminals to the corresponding overhead line wire and the ground circuit.

The voltage converted by the secondary windings is output through switches 1P and 2P along the corresponding wires of the power cable. For use in protection and measurement devices, the secondary windings are connected according to the "star" and "triangle" scheme, as shown in the picture for TV-110 kV.

To reduce voltage losses and accurate operation of relay protection, a special power cable is used, and increased requirements are imposed on its installation and operation.

Measuring TV are created for each type of power line voltage and can be switched on according to different schemes to perform certain tasks. But they all work according to a general principle — the conversion of the linear value of the power line voltage into a secondary value of 100 volts with exact copying and highlighting all the characteristics of the primary harmonics on a certain scale.

The transformation coefficient TV is determined by the ratio of the linear voltages of the primary and secondary circuits. For example, for the 110 kV overhead line in question, it is written as follows: 110000/100.

These devices also convert the primary load of the line into secondary values with the maximum repetition of all changes in the harmonics of the primary current.

In order to facilitate the operation and maintenance of electrical equipment, they are also mounted on

substation switchgears.

Current transformers are included in the overhead line circuit in a different way than TM: they simply cut into each wire of the line phase with their primary winding, which is usually represented by just one turn in the form of a direct current guide. This is clearly visible in the above photo.

The transformation coefficient of the vehicle is determined by the ratio of the choice of nominal values at the design stage of the transmission line. For example, if a power line is calculated to transport currents of 600 amperes, and 5 A will be removed on the secondary side of the vehicle, then the designation 600/5 is used.

In the power industry, two standards of secondary current values have been adopted, which are applied:

- ✓ 5 A for all vehicles up to 110 kV inclusive;
- ✓ 1 A for 330 kV and higher lines.

The secondary windings of the vehicle are connected to connect to protection devices according to different schemes:

- ✓ full star;
- ✓ incomplete star;
- ✓ Triangle.

Each connection has its own specific features and is used for certain types of protection in various ways. An example of connecting line current transformers and current relay windings to a full star circuit is shown in the picture.

This is the simplest and most common harmonic filter used in many relay protection circuits. In it, the currents from each phase are controlled by an individual relay of the same name, and the sum of all vectors passes through the winding included in the common zero wire.

The method of using current and voltage measuring transformers allows transferring primary processes occurring on power equipment to a secondary circuit on an exact scale for their use in the hardware of relay protections and creating algorithms for the operation of logic devices to eliminate emergency processes on the equipment.

In relay protection, the main working element is a relay — an electrical device that performs two main functions:

- ✓ monitors the quality of a controlled parameter, for example, current, and in normal mode stably maintains and does not change the state of its contact system;
- ✓ when a critical value is reached, called the set point or trigger threshold, it instantly switches the position of its contacts and remains in this state until the controlled value returns to the normal range.

The principles of forming circuits for switching current and voltage relays into secondary circuits helps to understand the representation of sinusoidal harmonics by vector quantities with their image on the complex plane.

The terminal element of the relay protection of the line is the output circuits. Their logic is also based on the use of intermediate relays.

The output circuits form the order of operation of the line switches and determine the interaction with neighboring connections, devices (for example, the level of a backup switch – off) and other

elements of the RPA.

Simple line protections may have only one output relay, the operation of which causes the switch to be switched off. In complex systems of branched protections, special logic circuits are created that work according to a certain algorithm.

The final removal of voltage from the line in the event of an emergency is carried out by a power switch, which is actuated by the force of the disconnection electromagnet. For its operation, special power circuits are supplied that can withstand powerful loads.

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